Authorship pattern and Collaboration Trends in Artificial Intelligence Research Publications in Russia: A Scientometric Study

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Abstract

The present study aim to analysis the Artificial Intelligence research publications in Russia during 2011-2020 and the data has been collected from SCOPUS online database. During the study period it is identified that, total number of 3788 research publications are contributed. Out of 3788 publications in Russia, highest productivity is record in the year 2020 with 969(25.58%) publications and the relative growth rate and doubling time is fluctuation trend. Filchenkov A., has highest contribution of the author with 22(0.58%) publications, 74(8.29%) citations and citation per paper is 3.36. During the study period 558 (14.75%) publications are single author's publications and 3230(85.27%) publications are multi author's publications. Average degree of collaboration is 0.85, Collaborative coefficient values are found fluctuation trend and average collaborative index is 3.48. Time series analysis study identified that the inference is a positive growth level in the year 2025 is 1182 publications and the year 2030 is 1583 publications in the field of artificial intelligence research publications in Russia. During the study period 83 countries are collaborated with 1343 publications in Russia

Keyword: Artificial Intelligence, Scientometric, Bibliometric, Russian Federation, Co-authorship Index

1. Introduction

Artificial intelligence is the study of mental faculties through the use of computational models. The word "intelligence" in the name of this field is misleading. As a consequence, it sounds as if 'artificial intelligence' were a technique for producing an abundance of clever insights. Artificial intelligence is concerned with the general behaviour that goes along with intelligence. In artificial intelligence we are constantly faced with choices in how we will design our programs and most of the time there is very little evidence as to how such choices should be made. The start the artificial intelligence McCarthy 1956 Dartmouth conference. This conference was first meeting of the four men who would lead artificial intelligence, at least in the United States for the next twenty years founding the field of artificial intelligence. The relatively little was accomplished at the conference, certainly little compared to the hopes of the organizers[1].

Every day use of Artificial Intelligence

Everyday influences of artificial intelligence are altering the way our daily lives. If someone from the 1950s travelled through time and arrived in 2019, they would marvel at the way we use our smartphones to navigate around town, how virtual digital assistants such as

Alexa and Cortana respond to our queries and would be baffled by our addiction to social media channels such as Facebook, Instagram and Twitter. What is now normal to us and powered by Artificial Intelligence, would be completely foreign to our friend from the past. There no doubt that artificial intelligence is an integral part of our daily lives. Our financial institutions, legal institutions, media companies and insurance companies are all figuring out ways to use artificial intelligence to their advantage. From fraud detection to writing news stories with natural language processing and reviewing law briefs, Artificial Intelligence reach is extensive[2].

Scientometrics

Scientometrics[3] can be defined as an application of quantitative techniques to scientific communication, which aims to measuring the impact of science on society, comparing the output as well as its impact at national and international levels. These include the measurement of impact articles, journals and institutes, understanding of scientific citations and mapping the research domains. A number of scientometric studies have been carried out based on research output of specific countries or institutions[4].

2. Review of Literature

Muneer Ahmad and Sadik Batcha (2021)[5] conducted the Russian contribution to Coronary Artery Disease research: A Scientometric mapping of publications during 1990-2019 from web of science database with 5058 publications. The study identified maximum of the document by article with 70.5%, maximum of contributions are 2nd block year 2010-2019 with 52.2%. Russian Academy of Medical Science produced by maximum of 576 publications. Top author by Barbarash OL with 100 publications and 620 citations during the period of the study.

Ramakrishnan Jagannathan, Ravi Sankar Govindan and Thavamani, Kotti (2021)[6] examined the analysis of authorship pattern and collaborative research in the field of Laparoscopic Surgery literature from the MEDLINE database during 2010-2019 with 77934 publications. The study identified that highest contributions of the year 2019 with 9118 publications. Multi authors are contributed maximum of 94.97% publications, degree of collaboration ratio in-between 0.92 to 0.97 and average CC had been identified 0.62.

Ashok S. Chaudhary, et al. (2021)[7] analyzed bibliometric study of SAARC countries research trends in Public Health using Scopus database during the year from 1957 to march 2021 with 1720 publications and 5758 authors. The study reveals that three most countries are India, Pakistan, Bangladesh and most productive journal was “Indian Journal of Public Health” and most productive author was Ramasam, Y. J with 57 publications.

Attas, Hashem Hussein, Rahaman, Safiqur; and Ansari, Khadeeja (2021)[8] conducted the Saudi Arabian research output on big data publications using Scopus database during 2015 – 2019 with 818 research publications. The study identified that maximum of 230 (28.12%) publications in the year 2019. 409(50%) of publications are published in the form of article. Relative growth rate (RGR) was recorded 2016 (0.866) while in 2019 (0.330), average

degree of collaboration was 0.91 and maximum of 29 (3.55%) research publications are published by "IEEE Access".

3. Objectivity of the Study

- To analysis the year wise growth of publications and citations
- To examine the relative growth rate and doubling time
- To analysis the top ten authors contribution
- To identify the top ten institutions contribution
- To examine the international collaborated countries
- To identify authorship pattern
- To analysis the degree of collaboration
- To analysis the collaboration co-efficient and collaboration index
- To analysis the co-authorship index
- To examine the time series analysis

4. Limitations

The present study focused the scientometric analysis of artificial intelligence research publications in Russian Federation were indexed in SCOPUS multidisciplinary online database from 2011 to 2020. This study has been used the following search strategy for data collection. The search key is ((TITLE-ABS-KEY ("Artificial Intelligence") AND AFFILCOUNTRY ("Russian Federation")) AND PUBYEAR > 2010 AND PUBYEAR < 2021). This study extracted a total number of 3788 publications are analyzed and classify using MS excel spreadsheet and data collected on 21.04.2021.

5. Data Analysis and Interpretations

5.1 Year Growth of Publication and Citations

Table 1 Year wise Growth

S. No	Year	No of Publications	%	No of Citations	%	CPP
1	2011	85	2.24	448	2.78	5.27
2	2012	75	1.98	649	4.03	8.65
3	2013	128	3.38	831	5.16	6.49
4	2014	214	5.65	2083	12.94	9.73
5	2015	265	7.00	2513	15.61	9.48
6	2016	371	9.79	2309	14.35	6.22
7	2017	349	9.21	1954	12.14	5.60
8	2018	606	16.00	2757	17.13	4.55
9	2019	726	19.17	1514	9.41	2.09
10	2020	969	25.58	1038	6.45	1.07
Total		**3788**	**100.00**	**16096**	**100.00**	**4.25**

Table -1 shows that, the year-wise growth of growth of publication in the field of Artificial Intelligence research in Russia during the study period of 2011-2020 with a total number of 3788 publications. From the study it is identified that, the highest productivity in the year 2020 with 969(25.58%) publications and the lowest numbers of publications were identified in the year 2012 with 75(1.98%) publications. Further it is identified that, total number of 3788 publications are received 16096 citations during the study period. Out of 16096 citations, highest number of citations are received in the year 2018 with 2757(17.13%) citations and the lowest number of citations are identified in the year 2011 with 448(2.78%) citations. During the study period highest CPP value in the year 2014 is 9.73 and the lowest CPP value in the year 2020 is 1.07.

5.2 Relative Growth Rate and Doubling Time

The relative growth rate and doubling time models are applied by Mahapatra, (1985)[9] and the same models are used for this study.

a) **Relative Growth Rate (RGR):** Relative growth rate is increased in the number of research publications/articles or pages per unit of time, and it can be calculated with the following equations.

$$R(a) = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

Where,

R (a) = RGR = the mean relative growth rate over the specific period of interval

W_1 = the logarithm of beginning number of publications/pages

W_2= the logarithm of ending number of publications/pages after a specific period of interval

$T_2 – T_1$ = the unit difference between the beginning and ending time periods.

Here the year can be considering the unit of time. The relative growth rate for the both publications and pages are calculated separately.

R (a) = Relative growth rate per unit of publications per unit of time

R (p) = Relative growth rate per unit of pages per unit of time

b). Doubling Time (DT): Doubling time is a direct relation between the relative growth rate and doubling time. If the number of research publications/articles/pages of a selected subject is double during the given period of the time interval. Difference has a value of 0.693 is used. Thus the corresponding doubling time for publications and pages can be calculated by the following equations.

$$Dt = \frac{0.693}{R(a)}$$

Table 2 Relative Growth Rate and Doubling Time

S. No	Year	No of Publications	Cum.	W_1	W_2	RGR = (W_2-W_1)	Dt = 0.693/RGR
1	2011	85	85.00		4.44		
2	2012	75	160.00	4.44	5.08	0.63	1.10
3	2013	128	288.00	5.08	5.66	0.59	1.18
4	2014	214	502.00	5.66	6.22	0.56	1.25
5	2015	265	767.00	6.22	6.64	0.42	1.63
6	2016	371	1138.00	6.64	7.04	0.39	1.76
7	2017	349	1487.00	7.04	7.30	0.27	2.59
8	2018	606	2093.00	7.30	7.65	0.34	2.03
9	2019	726	2819.00	7.65	7.94	0.30	2.33
10	2020	969	3788.00	7.94	8.24	0.30	2.35

Table 2 presents the relative growth rate and doubling time in the field of Artificial Intelligence research publications in Russia during the selected ten year study period. This study found that, relative growth rate is 0.63 in the year 2012 and 0.30 in the year 2020. At the same time doubling time is 1.10 in the year 2012 and 2.35 in the year 2020. This study confirmed that, relative growth rate is decreasing trend and doubling time is increasing trend but the year 2018 is some fluctuation in both RGR and DT due to sudden hike of the publications.

5.3 Prolific Authors on Artificial Intelligence Research in Russia

Table 3 Top 10 Authors Contribution

S. No	Name of the Author	No of Publications	% of 3788	No of Citations	%	CPP
1	Filchenkov, A.	22	0.58	74	8.29	3.36
2	Semenkin, E.	20	0.53	142	15.90	7.10
3	Brown, J.A.	18	0.48	38	4.26	2.11
4	Kuznetsov, S.O.	18	0.48	135	15.12	7.50
5	Smirnov, A.	17	0.45	107	11.98	6.29
6	Ignatov, D.I.	15	0.40	78	8.73	5.20
7	Khalyasmaa, A.I.	14	0.37	58	6.49	4.14
8	Talanov, M.	14	0.37	92	10.30	6.57
9	Kotenko, I.	13	0.34	78	8.73	6.00
10	Kovalchuk, S.V.	13	0.34	91	10.19	7.00
Total		**164**	**4.33**	**893**	**100.00**	

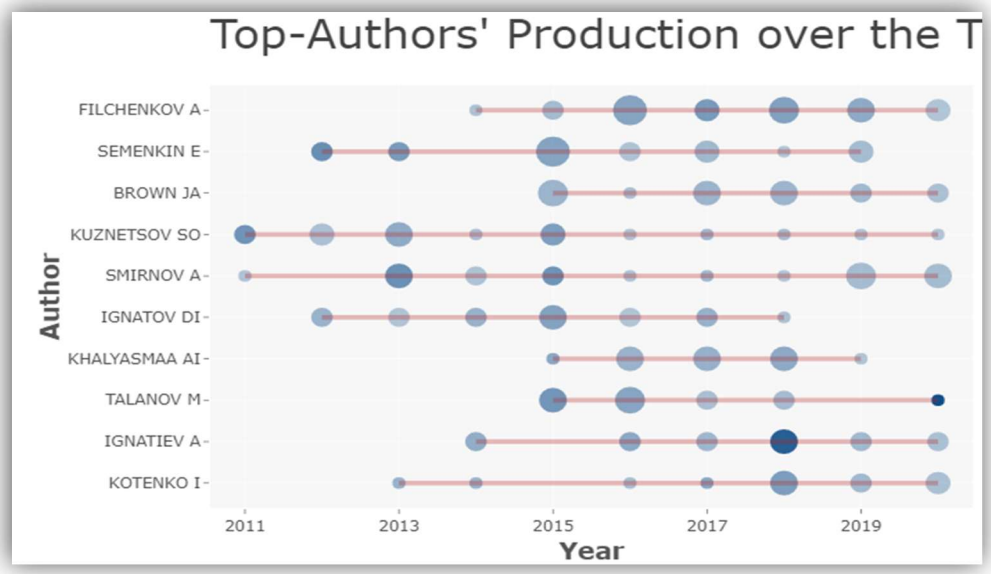

Figure 1. Top 10 author's contributions during the time from the biblioshiny application

Table 3 and Figure 1 shows that, the top ten author's contributions in the field of Artificial Intelligence research publications in Russia. From this study, it is identified that the highest number of 22(0.58%) publications are contributed by Filchenkov, A., and it is received 74(8.29%) citations and CPP is 3.36. Followed by Semenkin, E., has 20(0.53%) publications, 142(15.90%) citations and CPP is 7.10. Brown, J.A., with 18(0.48%) publications, 38(4.26%) citations and CPP is 2.11. Top ten authors are contributed 164(4.33%) publications and 893 citations in the study.

5.4 Research Publications by Top Ten Institutions

Table 4 Top 10 Institutions Contributions

S. No	Name of the Institutions	No of Publications	% of 3788	No of Citations	%	CPP
1	Russian Academy of Sciences	363	9.58	1100	11.44	3.03
2	National Research University Higher School of Economics	271	7.15	1405	14.61	5.18
3	Saint Petersburg National Research University of Information Technologies, Mechanics and Optics University ITMO	257	6.78	1476	15.34	5.74
4	Lomonosov Moscow State University	182	4.80	1775	18.45	9.75
5	Saint Petersburg State University	160	4.22	498	5.18	3.11

6	Moscow Institute of Physics and Technology	132	3.48	1084	11.27	8.21
7	Ural Federal University	129	3.41	426	4.43	3.30
8	Kazan Federal University	121	3.19	916	9.52	7.57
9	Peter the Great St. Petersburg Polytechnic University	115	3.04	633	6.58	5.50
10	National Research Nuclear University MEPhI	101	2.67	306	3.18	3.03
Total		**1831**	**48.34**	**9619**	**100.00**	

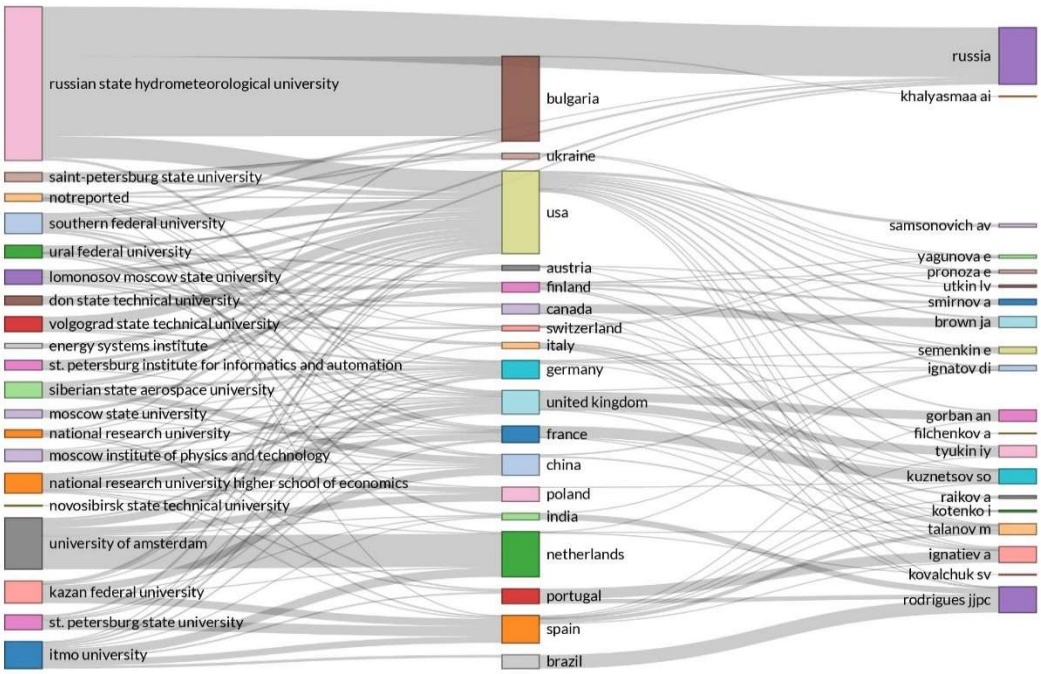

Figure 2. Top Institutions and its collaborated countries and author's from the biblioshiny application.

Table 4 and Figure 2 shows the top ten institutions contributions in the field of Artificial Intelligence research publications in Russia and its collaborated countries and authors. The study identified that, highest contributing institution is Russian Academy of Sciences with 363(9.58%) publications and it is received 1100(11.44%) citations, CPP is 3.03. Followed by National Research University Higher School of Economics is 271(7.15%) publications and 1405(14.61%) citations CPP is 5.18. Third placed by Saint Petersburg National Research University of Information Technologies, Mechanics and Optics University ITMO with 257(6.78%) publications and 1476(15.34%) citations and CPP is 5.74. This study found that top 10 institutions are contributed 1831(48.34%) publications and 9619 citations are contributed during the study period.

5.5 International Collaborative Countries Research Publications in Russia

Table 5 Top Ten Collaborated Countries

S. No	Name of the Country	No of Publications	% of 3788
1	United States	138	3.64
2	Germany	114	3.01
3	United Kingdom	113	2.98
4	France	75	1.98
5	Spain	57	1.50
6	Italy	47	1.24
7	China	46	1.21
8	Netherlands	40	1.06
9	Portugal	39	1.03
10	India	35	0.92
11	Others (73 countries)	639	16.87
Total		**1343**	**35.45**

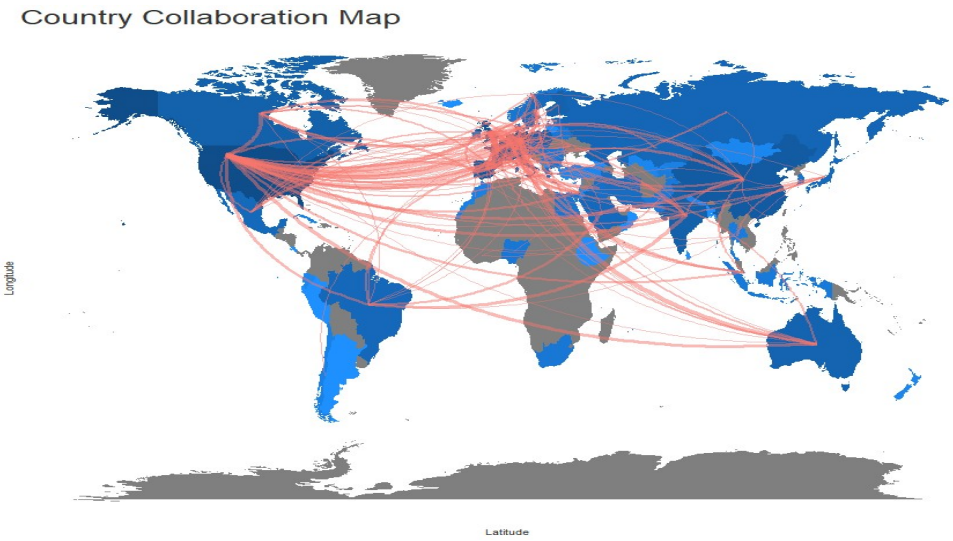

Figure 3 International collaborated countries in Russia from biblioshiny application.

Table 5 and Figure 3 shows that, top 10 collaborated countries in Russia in the field of Artificial Intelligence research publications during 2011-2020. This study identified that, maximum number of 138(3.64%) publications are collaborated by the United States. Followed by Germany with 114(3.01%) publications, United Kingdom with 113(2.98%) publications. India is 10th place collaborating country from Russia with 35(0.92%) publications. This study found that, out of 3788 publications in Russia, 1343(35.45%) publications are collaborated by 83 different countries during the study period.

5.6 Year-wise Authorship Pattern

Table 6 Year-wise Authorship Pattern

S. No	Year	Publications by No of Authors						Total Publications
		1	2	3	4	5	>5	
1	2011	20	34	13	9	2	7	85
2	2012	17	26	17	13	1	1	75
3	2013	23	39	29	21	4	12	128
4	2014	33	54	55	39	17	16	214
5	2015	40	66	70	39	23	27	265
6	2016	37	98	90	70	48	28	371
7	2017	49	80	98	56	34	32	349
8	2018	90	132	156	112	57	59	606
9	2019	92	183	173	126	78	74	726
10	2020	157	212	231	136	136	97	969
Total		**558**	**924**	**932**	**621**	**400**	**353**	**3788**
%		14.73	24.39	24.60	16.39	10.56	9.32	100.00

Table 6 presents the year-wise authorship pattern in the field of Artificial Intelligence research publications in Russia for the selected ten year study period. This study identified from table 6, only 558(14.73%) publications are a single authors publications and remaining 3230(85.27%) publications are multi-authors publications. During the study period maximum of 932(24.60%) publications are contributed by three authors, followed by two authors with 924(24.39%) research publications and 621(16.39%) publications by four authors. This study confirmed that, the majority of the publications are multi-authors.

5.7 Degree of Collaboration

Degree of collaboration denotes that the concentrations of single authors publication are relation to the multi-authors publication suggested the formula by Subramanyan (1983).[10]

$$DC = \frac{Nm}{(Nm + Ns)}$$

Where,
DC - Degree of collaboration for a specific subject for a selected study period

Nm - Number of multiple authors publication,

Ns - Number of single authors publication.

Table 7 Degree of Collaboration (DC)

Year	Single Author Publications	%	Multi-Authors Publications	%	Degree of Collaboration

	(Ns)		(Nm)		DC=Nm/(Nm+Ns)
2011	20	0.53	65	1.72	0.76
2012	17	0.45	58	1.53	0.77
2013	23	0.61	105	2.77	0.82
2014	33	0.87	181	4.78	0.85
2015	40	1.06	225	5.94	0.85
2016	37	0.98	334	8.82	0.90
2017	49	1.29	300	7.92	0.86
2018	90	2.38	516	13.62	0.85
2019	92	2.43	634	16.74	0.87
2020	157	4.14	812	21.44	0.84
Total	**558**	**14.73**	**3230**	**85.27**	**0.85**

Table 7 represents the year wise degree of collaboration in the field of Artificial Intelligence research publications in Russia. It is identified from the table 7 degree of collaboration is 0.76 in the year 2011, 0.84 in the year 2020 and average degree of collaboration is 0.85.

5.8 Collaborative of Co-efficient (CC)

The pattern of co-authorship collaboration among the authors can be measured with the following formula suggested by Ajiferuke, et al. (1988)[11]

$$CC = 1 - \left[\sum_{j=0}^{k} \left(\frac{1}{j}\right) \times Fj/N\right]$$

Where,

Fj = Number of publications with j author papers

N = Total number of the research publications

k = the greatest number of authors/ paper in the given field

Collaboration Index (CI) The simple indicator are presently employed in the publications to the collaboration index among the co-authors, which is to be understand nearly as the mean number of authors per paper are suggested by Ajiferuke, et al.(1988)[11]

$$CI = \frac{\sum_{j=1}^{k} jfj}{N}$$

Here

J - The number of co-authored papers appearing in a discipline

N - The total number of publications in the field over the same time period of interval and

k - The highest number of authors per paper in a same time field.

Table 8 Collaboration Co-efficient

Year	1	2	3	4	5	>5	Total	TMAP	CC	CI
2011	20	34	13	9	2	7	85	65	0.47	3.00
2012	17	26	17	13	1	1	75	58	0.48	2.86
2013	23	39	29	21	4	12	128	105	0.53	3.25
2014	33	54	55	39	17	16	214	181	0.56	3.37
2015	40	66	70	39	23	27	265	225	0.57	3.44
2016	37	98	90	70	48	28	371	334	0.60	3.46
2017	49	80	98	56	34	32	349	300	0.58	3.47
2018	90	132	156	112	57	59	606	516	0.58	3.53
2019	92	183	173	126	78	74	726	634	0.59	3.51
2020	157	212	231	136	136	97	969	812	0.57	3.60
Total	**558**	**924**	**932**	**621**	**400**	**353**	**3788**	**3230**	**0.57**	**3.48**

Table 8 shows that, year wise collaborative co-efficient and collaborative index in the field of Artificial Intelligence research publications in Russia. It is observed from table 8 collaboration between the authors of single, two, three, four, five, and above five author's research publications are segregated into year-wise. Further this study identified from table 8, the collaborative coefficient is 0.47 and 0.57 between the years 2011 and 2020. The average collaborative co-efficient is 0.57. At the same time, the collaborative index (CI) is 3.0 in the year 2011 and 3.60 in the year 2020. The average collaborative index is 3.48.

5.9 Pattern of Co-Authorship Index (CAI)

In order to assess the pattern of Co-Authorship Index (CAI), the following formula suggested by Garg and Padhi (1999)[12] has been employed.

Where,

Nij = Number of papers having authors in block i

Nio = Total output of block i , Noj = Number of papers having j authors for all blocks

Noo = Total number of papers for all authors and all blocks

CAI = 100 implies that a country's co-authorship effort for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort, and CAI < 100 lower than average co-authorship effort by that country for a given type of authorship pattern.

For calculating the co-authorship index for authors, years have been replaced by block. For this study, the authors have been classified in to two blocks, vz single, two, three, four, five and more than five authors and the results of co-authorship index as per the formula have been presented in the table 9.

Table 9 Co-authorship Index (CAI)

S. No	Block Year	Authorship Pattern												
		1	CAI	2	CAI	3	CAI	4	CAI	5	CAI	>5	CAI	Total
1	2011-2015	133	117.72	219	117.05	184	97.50	121	96.23	47	58.03	63	88.14	767
2	2015-2020	425	95.50	705	95.67	748	100.63	500	100.96	353	110.66	290	103.01	3021
Total		**558**		**924**		**932**		**621**		**400**		**353**		**3788**

Table 9 shows that, block year wise co-authorship index for Artificial Intelligence research publications in Russia for the selected ten year study period. It is observed from this study, CAI for single authorship contributed is 117.72 in the first block year of 2011-2015 to 95.50 in the second block year of 2015-2020. Similarly, CAI for two authorship also decreasing trend from 1st block to 2nd block. At the same time CAI for three, four, five and more than 5 authorship is increasing trend from 1st block to 2nd block.

5.10 Time Series Analysis vs. Year

Time series analysis is a sequence of well-defined data points measured to consistent the time intervals over the period of time. Time series forecasting the use of model to predict future values based on previous data[13]

Table 10 Time Series Analysis

S. No	Year	No of Publications Y	X	X^2	XY
1	2011	85	-5	25	-425
2	2012	75	-4	16	-300
3	2013	128	-3	9	-384
4	2014	214	-2	4	-428
5	2015	265	-1	1	-265
6	2016	371	1	1	371
7	2017	349	2	4	698
8	2018	606	3	9	1818
9	2019	726	4	16	2904
10	2020	969	5	25	4845
Total		3788		110	8834

Table 9 shows that the time series analysis formula has been predicted in the field of Artificial Intelligence research publications in Russia for the year 2025 and 2030.

Here, the straight line equation is

$Y = a+bX$

Here,

Y – Total number of publications = 3788

N – Total number of years =10

$a= \sum Y/N = 3788/10 = 378.8 = 379$

$b= \sum XY/\sum X^2= 8834/110 = 80.30$

Estimated publications in 2025 is when X = 2025- 2015 = 10

Y= 379+ (80.30*10) =379+ 803 = 1182

Estimated publications in 2030 is when X = 2030- 2015 = 15

Y= 379+ (80.30*15) = 379+1204.5= 1583.5 = 1583

From the study, time series analysis applications are applied by the year wise growth and the results are obtained separately for the year 2025, 2030. It is found that the future growth of research publications for the year 2025 will be 1182 publications and the year 2030 will be 1583 publications has been identified. The inference is that there is a positive growth level in the year 2025 is 1182 publications and the year 2030 is 1583 publications in the field of artificial intelligence research publications in Russia.

6. Major Finding

- During the study period total number of 3788 publications are received with 16096 citations. Maximum of 969(25.58%) publications are identified in the year 2020.
- This study identified relative growth rate is 0.63 in the year 2012 and 0.30 in the year 2020, at the same time doubling time is 1.10 in the year 2012 and 2.35 in the year 2020. This study confirmed that, relative growth rate is decreasing trend and doubling time is increasing trend but the year 2018 is some fluctuation in both RGR and Dt.
- Highest contributions of the author is Filchenkov, A. with 22(0.58%) publications, 74(8.29%) citations and citation per paper is 3.36
- Maximum contributions of the institution is Russian Academy of Sciences with 363(9.58%) publications, 1100(11.44%) citations and citation per paper is 3.03 citations.

- Out of 3788 publications in Russia, 1343(35.45%) publications are collaborated by 83 different countries and maximum of 138(3.64%) publications are collaborated by United States.
- This study identified that only 558(14.73%) publications are single authors and remaining 3230(85.27%) publications are identified multi-authors publications.
- During the study period average degree of collaboration is 0.85, collaborative coefficient is between 0.47 and 0.57 and average collaborative index is 3.48.
- Co-authorship Index is decreasing trend for single and double author's contributions and remaining three, four, five and above five authors CAI values are increasing trend from 1st block year to 2nd block year.
- Time series analysis study confirmed that, the inference is positive growth level in the year 2025 is 1182 publications and the year 2030 is 1583 publications in the field of artificial intelligence research publications in Russia.

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